Appendix 7:
An Analysis of Transport Survival

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Introduction

The transportation of juvenile salmon through the mainstem Columbia and Snake River hydropower system began as an experimental program in the late 1960s and has been the principal method for improving mainstem survival since the early 1980s (Mundy et al. 1992) Its justification rests on experimental results indicating transported fish return as adults in greater proportions than their non-transported counterparts. Although there are problematic aspects to this research (Mundy et al. 1994) and although a recent sensitivity analysis indicates the ratio of transport to control returns is potentially less than reported (Ward et al. 1995), it appears that transportation has generally increased the returns of Snake River spring chinook.

But although transportation has occurred ever since Lower Granite Dam was closed in 1975 and has been fully operational since the early 1980s, Snake River spring chinook have continued to decline. These declines have shifted focus from comparisons with inriver fish to questions about the absolute survival of transported fish. Specifically, the PATH decision tree asks if the continued declines of Snake River stocks are due to survival that is too low to support rebuilding or, instead, if there are not enough fish being collected. This analysis addresses the first question.

In addition, in recognition of there being differences in upstream adult survival among the groups, this analysis correct for those differences to determine the extent to which differences in adult survival explain differences in SARs.

Methods

This analysis compares the estimated smolt-to adult return (SAR) data from transport studies with two other sources of SAR data. The first comparison is between the transport SAR data and SAR estimates for the Snake River for the period immediately before an era of extensive dam construction that occurred in the late 1960s and early 1970s. This is, in essence, a before and after comparison. The second comparison presented is between the transport SARs and contemporaneous SARs from the Warm Springs River, an Oregon stream that is above two dams and therefore assumed to be far less impacted by the hydropower system. This is an upstream versus downstream comparison.

Mundy (1996) provides survival estimates of transported fish from the time they are marked as smolts at the uppermost dam until they return as adults to the uppermost dam. He includes comments on the usefulness or problems associated with specific years. This analysis includes only data from 1975 and on because it represents the current configuration of projects. Data for barged, not trucked fish were used. Furthermore, this analysis focuses on years are believed to be representative of transport efficacy (1983 - 1990) and discounts years that are less reliable because the problems had not been worked out (1975 - 1979) Mathews (pers. comm.) However, the survival rates reported by Mundy (1996) were not adjusted to account for adult trap efficiency. Mathews (pers comm.) stated that trap efficiencies were characteristically in the 30% - 50% range and suggested 40% as a reasonable value. Therefore, survival values in Mundy et al. (1996) were multiplied by 2.5. Also, to allow comparisons with the SAR data from the 1960s which were expanded to include river harvest (Raymond 1988), the transport SARs were adjusted upward to

account for inriver harvest. I used the average TAC harvest rate of the two years, lagged four and five years beyond their brood year, which acknowledges that the bulk of the fishery is four and five year olds. Finally, to permit comparisons with other data sets involving stocks that are predominately if not entirely wild, transport SARs were raised by a factor of 2.35 because in the one year where such a breakdown was attempted, the SAR for wild fish was 2.35 times the mixed hatchery/wild transport SAR.

For the before and after approach I used SAR data directly from Raymond (1988). Although that author estimated SARs from 1964 through 1984, only years 1964 through 1967 were used because they represent a time period prior to an era of intensive dam construction in which four dams were closed in eight years. Thus 1964 through 1967 is generally felt to represent a time during which Snake River stocks were believed to be reasonably healthy.

SAR data for the Warm Springs came from two sources. Smolt estimates from the Warm Springs fish trap were provided by Mark Fritsch (pers. comm.). Estimated number of recruits to the mouth of the Deschutes were provided by Howard Schaller (pers. comm.) Resultant SARs were raised to account for inriver harvest by using the TAC harvest rate lagged four years past the brood year because four year olds dominate the catch.

Finally, all SARs were adjusted for adult upstream mortality for the purpose of determining if differences in SARs are due to adult mainstem mortality or, conversely, if there is any delayed mortality of transported fish. Estimates of conversion (adult upstream survival) for 1979 to the present (TAC 19xx). For years prior to 1979 I calculated the average for the first five years of the series (1979 - 1983). For transported fish, I adjusted the SAR for the entire eight project reach. Because the Raymond data represented an era with four projects, I assumed the adult survival to be twice the total and used the square root of the product of the two reaches (Columbia and Snake River) for the average of the 1979 -1983 period. For the Warm Springs I assumed the adult mortality was half of the Bon - McN reach and took the square root of the adult survival for that reach. In all cases, the adult survivals were lagged by the same number of years used to lag harvest rates. To make the adjustments, I divided the uncorrected SARs by the appropriate adult survival rates.

Results

The results of this analysis are shown in Figure C6 A7-1.

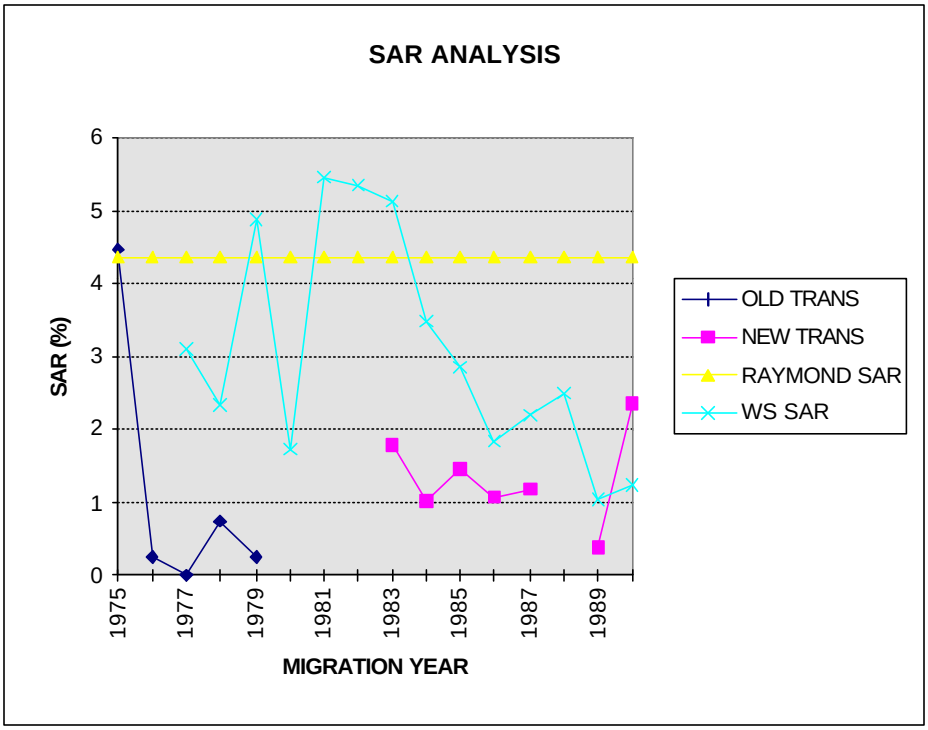

Figure C6 A7-1: A comparison among SARs from transportation studies, from the Snake River in the mid 1960s (Raymond) and from the Warm Springs River in Oregon (WS).

With regard to the before and after comparison, the mean SAR from Raymond (1988) of 4.35% is greater than the SAR from transported fish which is 1.33% for the reportedly more reliable period of 1983 through 1990. Note that Raymond's estimates include some hatchery fish in two of the four years and may therefore be conservative with regard to this analysis.

The contemporaneous upstream - downstream comparison between transport SAR and Warm springs SAR indicates transported fish survive at a lower rate than downstream non-transported counterparts that are less affected by hydropower development and operation. The Warm Springs mean SAR was 3.07% for the entire period and 2.53% for the 1983 - 1990 period. Decreased SARs in the Warm Springs are believed to be primarily the result of severe drought and may be atypical of the performance of this or other streams that are similar in terms of habitat quality and hydropower impacts.

A secondary objective of this analysis was to correct SARs for differences in adult, upstream survival in an attempt to determine if differences in SARs are simply due to differences in adult survival. SARs corrected for adult survival are shown in Figure C6 A7-2.

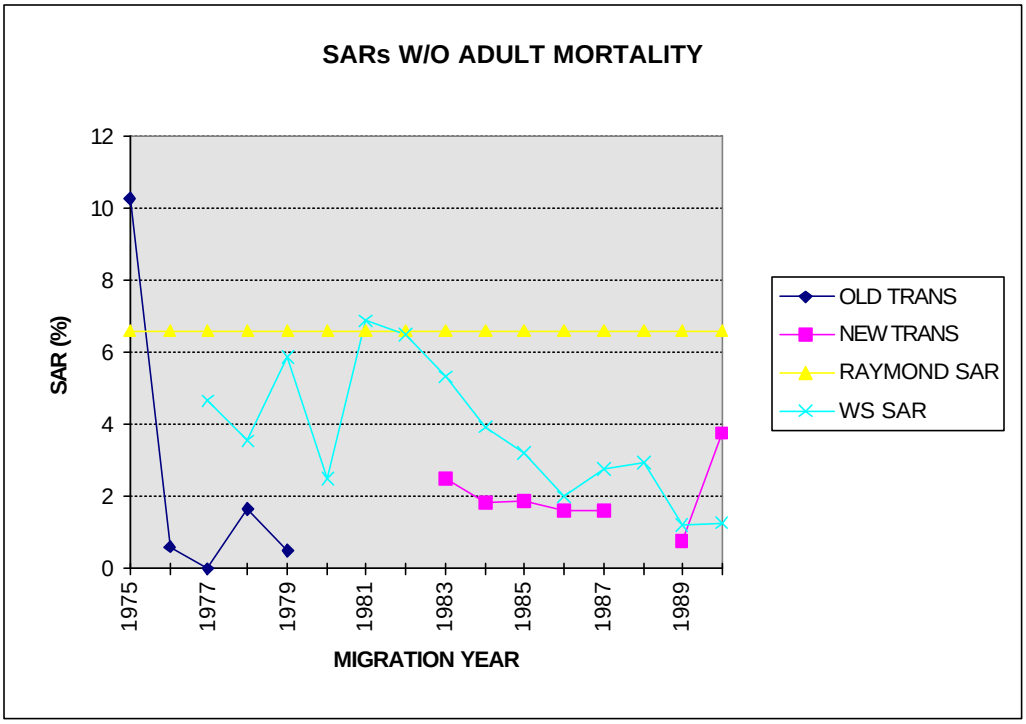

Figure C6 A7-2: SARs for transported fish, Raymond data and Warm Springs data correct for differences in adult survival.

SARs of transported fish fell below those for the Warm Springs fish in all but one year of the more recent time series and fell well below those reported by Raymond (1988). These results indicate differences in SARs to some extent, but not entirely, due to differences in adult upstream survival. This in turn indicates lower transport SARs are due to delayed mortality.

Discussion

Results of this analysis indicate the SAR of fish transported from the Snake River is lower than it was prior to the era of intensive dam construction and lower than the SARs of the Warm Springs spring chinook, the only down river indicator stock for which contemporaneous SAR data are available. To the extent homing or straying are problems, they could also contribute to lower SARs of transported fish.

The similarity between Raymond's SAR data from the 1960s and those from the Warm Springs River indicate the SARs for Snake River fish are below those that would lead to rebuilding. The SARs for transported fish are generally lower than those with which they are being compared. For recent transport years (1983 - 1990) transport SARs are well below SARs estimated for the mid 1960s. While this could conceivably be due to some other factor such as differences in ocean survival, they are also below Warm Springs SARs. In only one of seven years does the transport SAR exceed the Warm Springs SAR and only then during a period of low SARs in The Warm Springs thought to be anomolously low because of problems within the subbassin.

Any discussion of these results must be accompanied by a discussion of the data and assumptions that went into the analysis. The goal of this analysis was to provide valid comparisons of estimated SARs for wild fish with harvest taken into consideration and, for transported fish, trap efficiency.

Data on annual inriver harvest rates are available and believed to be accurate. Data on conversion (adult survival rates is also good since the mid 1980s but historic rates are unavailable. The estimate of adult trap efficiency, was based on information collected over a number of years, but was not available on a year specific basis. The factor used to raise transport SARs so they represent the wild component was based on one years data in which an attempt was made to disaggregate the mixed transport returns into wild and hatchery components. Because this estimate was made in only one, seemingly anomalous year underlines the need for better estimates in this area in particular. In 1997 there are no plans to tag anything but hatchery fish which means this source of uncertainty may not be addressed in the near term.

The limited SAR data for wild stocks points out the need to obtain measurements for other stocks to assure that the Warm Springs stock is not atypical of other stock that are situated similarly and appear to be in a similar state of health. This would seem to be as important as tagging inriver controls as part of transportation research.

Correcting SARs for differences in adult upstream survival indicates differences in SARs are due to some extent, but not entirely to differences in adult survival. Because of the widespread belief in the region that survival of fish while they are in the barge is good, in excess of 90%, depressed SARs is an indication of delayed mortality.

Recommendations

This analysis illuminates the need for more information to properly evaluate the efficacy of transportation. Specific items include:

1. Annual estimates of adult trap efficiency.

2. Annual estimates of wild and hatchery SAR estimates.

3. Annual estimates of SAR for additional downriver indicator stocks.

4. Review and, if necessary, reanalyze hatchery CWT data recently analyzed by Coranado Hernandez to determine if SAR estimates for hatchery stocks have upstream/downstream differences.

Literature Cited

Coronado-Hernandez, M.C. 1995. Spatial and temporal factors affecting survival of hatchery-reared chinook coho and steelhead in the Pacific Northwest. Doctoral dissertation, University of Washington. 236p.

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TAC (Technical Advisory Committee for U.S. vs. Oregon) 1996.

Ward D. (transport sensitivity)